

## Bidirectional Reflectance Properties of Planetary Surface Materials

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The JPL spectrogoniometer is capable of measuring the bidirectional reflectance properties of planetary surface materials for arbitrary viewing geometries including small phase angles (Smythe et al., 1986a,b). These measurements depend on the textural characteristics of the regolith, particularly its packing state, and the albedo of the surface, which dictates the degree of multiple scattering. In general, porous, dark surfaces should exhibit the largest opposition surges. Our laboratory measurements on the JPL spectrogoniometer over the past year have concentrated on separating the effects of surficial texture and albedo. Figure 1 (Smythe et al.) for example, which represents a comparison of compacted and fluffy basalt, demonstrates that if all other factors such as normal reflectance and composition are equal, less densely packed surfaces exhibit more sharply peaked phase curves near opposition.

However, dark, porous surfaces are not the only ones with large opposition effects. Although very dark materials (e.g., carbon black) exhibit large surges, our measurements of compact barium sulfate show significantly non-linear increases in intensity, similar to, though somewhat smaller than the large surges exhibited by very dark materials (e.g. carbon black).

The range of materials measured over the past year include charcoal, several types of basalt, barium sulfate, sulfur, sugar, magnesium oxide, several clays, and halon.

Understanding the opposition effect requires a threefold attack: laboratory measurements, the comparison of these measurements with remote sensing observations, and the development of a theoretical model to describe both sets of data. We have extended our comparisons of laboratory measurements to remote sensing data. Figure 2 shows a comparison of IUE observations of Io with our measurements of fluffy basalt (~90% void space) and a theoretical model. The UV geometric albedo of Io is comparable to the normal reflectance of our sample. Our results suggest a fluffy regolith for Io, similar to that expected from the deposition of material falling from volcanic plumes. This result contrasts with our finding last year that Europa most likely has a compact surface with about 25% void space.

A number of technical improvements have been made to the goniometer during the past year. First, the quartz beam splitter we utilized to achieve normal incidence and emergence angles introduced unacceptable secondary reflections into our apparatus. A pellicle beam splitter manufactured by Oriel Corporation was substituted with success -- the secondary reflections disappeared entirely. Secondly, we found that mechanical stability is a major controlling factor in achieving small phase angles. We found that sufficiently accurate alignment of the laser, beam splitter, sample holder, and detector could be attained only by completely substituting optical XYZ mounts for optical rails and jacks.

We incorporated a Mie scattering program into our theoretical model (Buratti, 1985). The purpose of this approach was to explain the opposition surges we observed in samples that are not dark and porous. As yet we have not been able to explain these surges as Mie scattering phenomena.

#### REFERENCES

Buratti, B., 1985. "Application of a Radiative Transfer Model to Bright Icy Satellites." *ICARUS*, 61, 208-217.

Smythe, W., Buratti, B., Nelson, R., Hapke, B., Gharakhani, V., 1986a. "Reflectance Measurements of Planetary Surface Materials at Small Phase Angles." *B.A.A.S.*, 19, p. 761.

Smythe, W., Buratti, B., Nelson, R., Hapke, B. Gharakhani, V., 1986b. "A Spectrogoniometer for Measuring Planetary Surface Materials at Small Phase Angles." *Applied Optics*, submitted.

This work was supported by Grant # NAS 7-918.

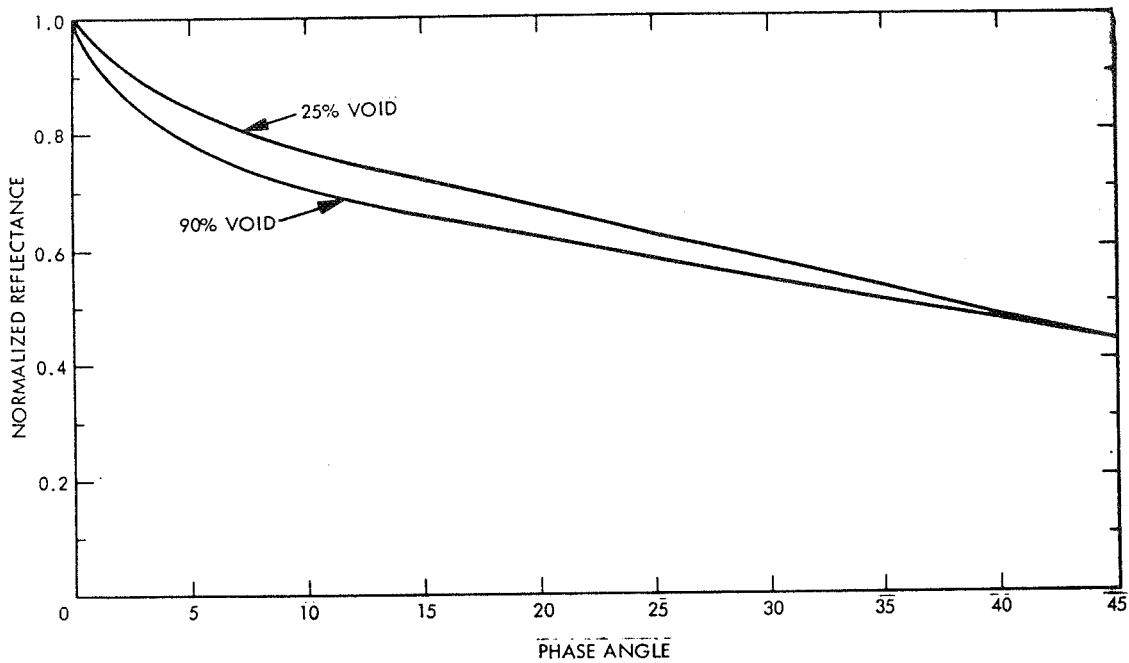


Figure 1. A comparison of fluffy (~90% void) basalt and dense (~25% void) basalt showing that fluffy regoliths exhibit larger opposition surges than dense ones.

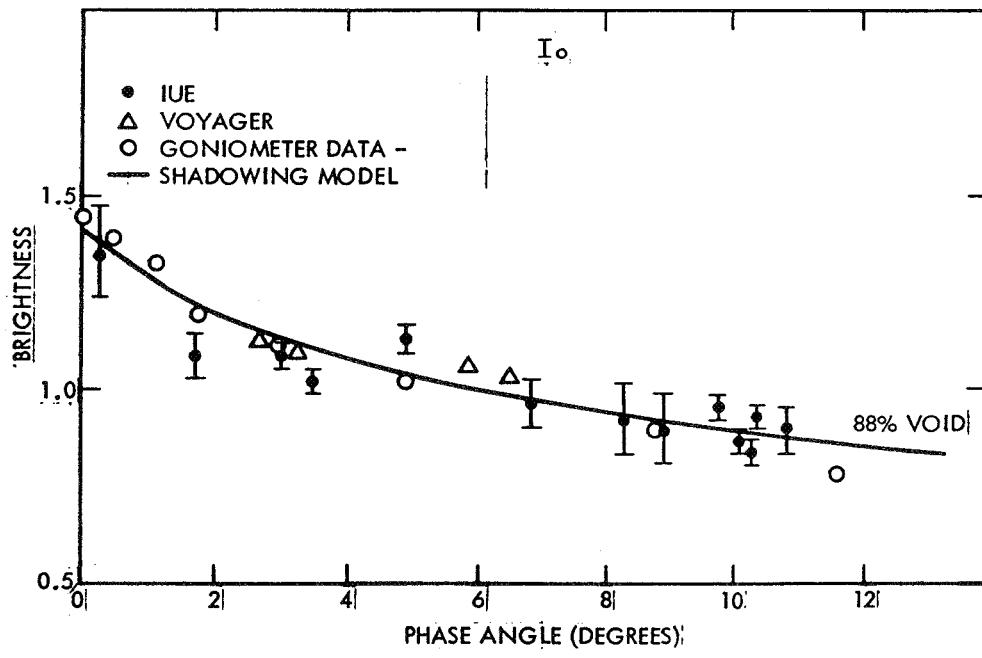


Figure 2. A comparison of fluffy basalt of about 90% void space with remote sensing observation of Io and our theoretical model. Data are normalized to unity at 6 degrees.